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CORRELATION

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Interpretation of Correlation.—Webb (35) believes that he has discovered another general cause of correlation among mental processes which should be added to the general intellective factor of Hart and Spearman. His new factor is conative in character and is described by its advocate as "persistence of motives." To determine its generality he uses Spearman's criterion that the correlation of columns of coefficients must approach 1.00. Webb's intercolumn correlations average .94 with a selected table of partial coefficients, after eliminating the general intellective factor. In preparing his table of coefficients he chooses those traits of character which show the largest difference in their correlations with "profoundness" and "quickness." Whether or not his factor is completely general, it seems as if his method might be utilized in empirically discovering common factors. The large mass of correlation data on careful estimates of nearly fifty different personal traits for a group of boys and a group of men, their intercorrelations and evaluation for the general intellective factor makes this one of the most important quantitative investigations of personality which has been attempted. It will be reviewed separately in the BULLETIN.

Building on Spearman's theory of a general and specific factors, Carey (7) makes the first systematic attempt to determine the nature of specific factors. Important conclusions as to the generality of discrimination and memory are reached by tests on

sensory discrimination, sensory memory, verbal memory, general intelligence, and by other data. No common activity of the nature of sensory discrimination is found after eliminating the general factor. Any specific factor of this type is of the nature of content. There appears to be a small general memory factor as well as a common factor of content in memorizing. Painstaking is not as general a factor as has been supposed. On the whole specific factors are probably numerous. They can be of the nature of act or of content. All except the motor factor are very limited in range. If the general factor is admitted, he finds support for Thorndike's earlier view of the specific nature of mental processes, and of Sleight's results. Kelley (19) gives the best evidence as to the existence and continuous effect of specific factors when he shows that the abilities which differentiate success in English from success in mathematics persist from the elementary school to high school, the *differences* in the marks correlating .515.

The general common factor is confirmed by Webb (35) and Giese (12), while Damm (9) concludes from his study of sensory discrimination limens that the central factor is the span of attention. Moore (23) issues a warning against assuming that the correlation coefficient always is the best measure of the relationship between two variables even when they show normal correlation. He provides a formula which exhibits r as a function of the underlying variable quantities that determine x and y and the relationship between them.

The interpretation of correlation through heredity is discussed by several investigators. Considering the suggestion of Brown that the general factor might be environmental, like family discipline, Spearman (32) argues that it would then affect a part and not the whole of the correlations. If part of the correlations were affected by such an environmental factor and part by innate ability then two such diverse causes would not give the correlations of correlations approaching 1.00, which he finds. The general common factor is innate, but the development of specific factors is unquestionably influenced by environment. He also makes the interesting suggestion that correlations between siblings may not fully express the hereditary relationship because of important pre-natal causes of individual differences, suggested by the work of Johannsen. Peters (27) traces family resemblances in school marks for three generations, and sibling correlations with a few tests. Unfortunately his frequent use of Yule's "Q" for calculating correlations

mars his results. Pearson's four-fold coefficient, however, gives a coefficient of .37 between parents and children for average marks and .42 for siblings, .46 for brothers and .62 for sisters. There must be some alternate inheritance since relatively more children get the middle mark when both parents had this mark than when one had better and the other had worse marks than this. The points indicating the chief importance of heredity are: The facts of alternating inheritance; the different resemblance between parents and children in different school subjects, the child tending to follow one parent in all subjects; the influence of sex upon resemblance, the mother having a stronger influence than the father, the grandfather than the grandmother; the closer resemblance of siblings of about the same age, those of wider differences in age having their resemblance reduced by the influence of maturity; the influence of grandparents in cases not influenced by parents. He finds support for the Mendelian principles of inheritance and Galton's law of filial regression. Further argument for heredity is found (33) when those siblings at corresponding ages who have been longer under the varied training of an institution show no less resemblance than those under a common home influence. Work with the Stanford measuring scale (34) shows that the correlation of intelligence with social status decreases with the older children and longer environmental influence.

Method.—The contributions to method include papers by Pearson (24) and Isserlis (18) developing and illustrating formulae for partial and multiple correlation ratios. Ritchie-Scott (29) makes the variate difference correlation method more useful by a table for facilitating the calculation of its error. There are also papers on the reliability of the coefficient of mean square contingency (25) and the correlation coefficient (11). Damm (9) shows that the two values of the correlation ratio may differ as much as .42, so that it is hardly safe to use either one alone, as has been advised. He finds that the Pearson formula for transposing coefficients obtained by correlating ranks gives only one tenth of the correction empirically discovered with his data by actually using both methods. He also finds that Spearman's earlier formula for eliminating errors of observation is faulty when tested by Brown's criterion. Spearman (32) shows the method by which one can measure the strength of the general factor in a particular individual. He believes the general factor admits "to a large extent in practice of as definite measurement as the length of the arm or the circumference of the head."

New Applications.—The partial regression equation is applied extensively in the field of applied psychology for the first time by Kelley (19). He sets a model for scientific work in vocational guidance by showing how it is possible to predict scholastic success in high school on the basis of grammar-school marks, estimates of elementary-school teachers, or tests. His quantitative analysis of the correlates of scholastic success enables him to make such a statement as the following before the student begins his high-school classes: Student No. 157 is most likely to be 1.070 times the standard deviation above the mean mark in the high-school class in algebra, +.563 S.D. in English and +.552 S.D. in history. With a group of 33, for whom all three forms of data were available, the prediction correlated with success in general scholarship in the first year of high school as high as .89. The partial regression equation enables the investigator to give the parts of a test, separate tests, or different forms of data each their proper weight in a prediction. For example the bearing upon average class standing of estimates of intellectual ability, conscientiousness, interest, and oral expression are weighted as 8 : 4 : 2 : 1. Kelley also uses Brown's method of stating reliability in addition to the usual reliability coefficient. Gray (13) applies the partial regression equation to weighting the various factors on a score card for handwriting. Thus weighted, the factors for size, neatness and spacing of letters show considerable variation from the estimate of competent judges as to the relative influence of these factors in general merit. Short methods for extending a regression weighting beyond four factors promises to raise some difficult problems. Pearson and Jaederholm (26) by use of the regression coefficient find that the average correction for the Binet-Simon scale to be added to each mental age from 7 to 14 years is .0953 × chronological age —.7769. The regression is linear and a year's growth in intelligence is found to be a valid unit of measurement at these ages.

Correlation is recognized as affording the best approach to an empirical analysis and classification of personal traits. In an intensive study Damm (9) makes this analysis on the basis of exact laboratory experiments on the difference limens for the discrimination of intensities of sounds, saturation of colors, visual and cutaneous space percepts. The results differentiate his subjects into groups, one of which shows similar memory performances by high correlation of their individual variabilities in judgment, another showing one-sided memory performances in the different fields, and

a third mixed group. There seems to be no correlation between the constant errors of the subjects in the different fields, and only medium correlation for their individual variabilities. Giese (12) looks for sex differences in correlations and finds that they are pronounced. Men have higher coefficients, which corroborates the idea that the male type is more variable. The biological laboratory through Harris (14) contributes an important study by the correlation of steadiness and accuracy of judgment for three observers making over 15,000 estimates of the number of beans in moderately large samples. The personal equation, shown by the constant error, seems to be remarkably little influenced by experience while the steadiness of the judgment increases with practice.

The correlations between the general merit of teachers and 45 different qualities estimated by school officers shows, according to Boyce (5), that the qualities most closely correlated with general merit represent results and technique of teaching, while those least correlated were professional and academic preparation, physical health and voice. Whiting (36) finds that while temperature, pulse and respiration have no diagnostic value for mentality, the last two show so little correlation with age, environment or occupation as to make them serve as possible supplements for finger prints as methods of identification. The Stanford revision of the Binet-Simon scale (34) correlates .40 with social status, and .45 with school success. Winch (37) finds the correlation of spelling abilities of equivalent groups was reduced from .99 to .65 by teaching them spelling by different methods. The direct method proved better. Houser (17) finds spelling correlates better with intelligence than does meaning of vocabularies.

Other Applications.—Illustrating the increasing use of correlation in testing tests, Chapman (8) and Hollingworth (16) investigate the important relation between initial scores and scores after practice. For the effects of practice see also Harris (14) and Damm (9). Giese (12) finds that combinations of tests present uncertain intercorrelations which tend to be reduced in amount. Of 24 intercorrelations over .70 none were for combined tests. The average of teachers' estimates of the difficulty of words for spelling correlates .79 with the empirically discovered order of difficulty, according to Buckingham (6); but there are wide variations so that one-fourth of the teachers judged that word easiest or next to the easiest which was the hardest. Downey (10) finds judgments of mirror script are specialized. While the opposites test and color naming show

a high correlation with articulation time, their relation to each other is not all explained by this articulation time, as is shown by the partial correlation with Hollingworth's data (15). Tests give reliable estimates of scholastic ability, but Kelley (19) finds that his tests were of less value than combined school marks for a number of years or combined teachers' estimates. Römer (30) finds that individual reactions with the free association test are a legitimate criterion of intellectual development. It is important to know for the first time that mental tests given a year apart to the same group correlate .71, as is shown by Woolley (38). The relation between manual and mental tests is low, .33 at 15 years. Chapman (8) finds practically no relation between the improvabilities of college students in five different tests. With only a few samples arranged in an order of merit, Adams (1) finds that this method is not adequate for testing the business value of advertisements.

The relationship of school marks has been studied by a number of investigators. Bobertag (4) traces the records of 53 pupils for nine years showing the intercorrelations of 11 school studies. German, the native language, shows on the whole the highest correlation with total marks, .90. Both he and Margis (22) point out the difficulties in using school marks for studying relationships of abilities. For example, when the first three years are combined, mathematics shows the highest intercorrelations, and for the last years in the Realgymnasium it is the lowest. Kelley (20) finds no greater break in marks from senior high school to university than between college years. Rietz (28) shows that the correlation between mathematics and law amounts to .528. Schüssler (31) finds low correlations between school marks for mathematics and singing for two different groups of a thousand pupils each. Correlations of the Courtis-test results for simple arithmetical operations are shown by Baldwin (2) and Bell (3) to be about .40. Bell finds little relation between the speed and accuracy indices. Lyon (21) makes an important distinction in that quickness of learning is correlated positively with recall, .5 to .6, but not with per cent. of time saved in relearning.

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PSYCHOPHYSICAL MEASUREMENT METHODS

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It is obviously of the greatest possible interest to obtain a single expression which expresses the course of the psychometric functions with equal accuracy for all individuals and for all possible experimental conditions. The number of influences which affect the curves of these functions is so great that it is doubtful if such an expression may ever be obtained. Such an expression would be obviously in the nature of an hypothesis about the psychometric